Life Tables in the Measurement
of Mortality and Longevity

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THE LIFE table, which provides detailed information on survival, has numerous applications. In public health, the life table may be uséd in assessing the health status, health trends, and health needs of communities. In addition, the life table is a basic tool in demography and is frequently used in estimating, projecting, and analyzing population changes. The data contained in the life table may also be applied in planning services for the population, such as prediction of markets, location of schools, extension of pipelines, and construction of hospitals.

By providing statistical values of expectation of life and probability of death and survivorship, the life table performs two basic functions. Not only does it summarize the mortality experience of a selected population group during a specific calendar period, but it makes possible the comparison of mortality experiences in two or more population groups. Such comparisons may be of two types: on the one hand, it is possible to compare the mortality experiences of a particular population group during two, or more, calendar periods, for example, U.S. white males in 1900 and 1958; on the other hand, two, or more, different population groups may be contrasted on the basis of their mortality experiences during the same calendar period, for example, U.S. white males and white females in 1958.

Two types of life tables—the generation life table and the current life table—should be distinguished. The former provides a longitudinal perspective by following an actual genera-

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tion of births, or a cohort, from the moment of birth through consecutive ages in successive calendar years. Based on the age-specific mortality rates of the cohort, which are observed during individual calendar years of exposure, the generation life table reflects actual mortality experience of the cohort throughout its lifetime.

This article is concerned only with the better known current life table, which is built upon the assumption of a hypothetical cohort, born during a particular calendar period and subject to the age-specific mortality rates observed in an actual population during the same period. Thus, for example, a life table for 1958 assumes a hypothetical cohort born in 1958 to be subject throughout its lifetime to the identical age-specific mortality rates prevailing in the actual population in 1958. No allowances are made for year-to-year changes in age-specific mortality as the hypothetical cohort passes through life.

In the life table, except for the purpose of computing mortality rates, the age distribution of the actual population is disregarded. No provision is made for such factors as migration and fertility, which affect age distribution in an actual population. These stipulations are desirable from the point of view of comparing mortality experiences in two or more population groups. Elimination of factors other than mortality keeps to a minimum the number of variables which may limit comparability of mortality experiences.

Federal Life Table Program

Three series of life tables are currently prepared in the National Office of Vital Statistics: complete, abridged, and provisional. Complete

life tables for the U.S. population, which are based on decennial census data and deaths for a 3-year period centered around the census year, have been prepared at 10-year intervals since 1900. Life tables in this series prior to 1929–31 did not cover the entire U.S. population, but were limited to the population included in the death-registration area.

Since 1945, the National Office of Vital Statistics has also issued, annually, abridged life tables based on deaths occurring during each calendar year and midyear postcensal population estimates provided for that year by the Bureau of the Census. The 1945 abridged life tables were prepared for white and nonwhite males and females; from 1946 through 1956, abridged life tables for the total population were added; and, since 1957, abridged life tables have also been published for total males and total females (1).

The demand for information regarding even more up-to-date life table values has been responsible for the introduction of a third series, provisional life tables. Starting with 1958, these provisional life tables have been published, for the total population only, in *Monthly Vital Statistics Report*, Annual Summary, part 2.

Life Table Values for 1958

Expectation of Life

Perhaps the best known of the life table statistics are estimates of expectation of life (e^{o}_{x}), which indicate the average remaining lifetime, in years, of persons who have attained a given age (x). Of the range of expectation of life measures, the most widely used is the average duration of life or expectation of life at birth (e^{o}_{0}). This measure represents the average number of years that the members of the life table cohort, at the time of birth, may expect to live. In table 1 are shown e^{o}_{0} values based on the mortality experience of the population during 1958 (2,3). The expectation of life at birth is 67.2 years for white males, 73.7 years for white females, 60.6 years for nonwhite males, and 65.5 years for nonwhite females. These values reflect the greater longevity of females over males and of whites over

nonwhites. Expectation of life at birth for white females is 6.5 years longer than that for white males, and the corresponding excess for nonwhite females is 4.9 years. It may be noted, however, that despite the greater longevity of females over males the differential in expectation of life at birth as between color groups is so great, that e^{o}_{0} for white males exceeds that for nonwhite females by 1.7 years. As table 1 indicates, the sex and color differentials which characterize expectation of life at birth prevail, in varying degrees of magnitude, for expectation of life at subsequent ages as well.

Expectation of life at birth is sometimes used to assess comparative health conditions in two or more populations. It is necessary to exercise caution when utilizing the average duration of life values in this manner. It should be remembered, when comparing e^{o}_{0} values for different populations, that a population which exhibits a high expectation of life at birth may actually have a high proportion of chronically ill individuals, particularly at older ages.

Expectation of life at birth is weighted considerably by the relatively large number of deaths occurring during the first year of life. In comparing the mortality experiences of two, or more, populations, it is sometimes preferable to consider expectation of life at age 1 (e^{o}_{1}), since this measure is not affected by the infant mortality situation. Indeed, as shown in table 1, e^{o}_{1} is higher than e^{o}_{0} in all population groups;

Table 1. Average remaining lifetime (e^{o}_{x}) at specified ages, by sex and color, United States, 1958

Sex and color	e^{o}_{0}	e^{o}_{1}	e^{o}_{20}	e^{o}_{65}
Total	69. 4	70. 4	52. 2	14. 0
Male	66. 4	67. 5	49. 4	12. 6
White	67. 2	68. 1	50. 0	12. 7
Nonwhite	60. 6	62. 8	45. 0	12. 1
Female	72. 7	73. 5	55. 2	15. 4
White	73. 7	74. 2	55. 9	15. 4
Nonwhite	65. 5	67. 3	49. 3	14. 8
Excess, female over male (years):				
Total	6. 3	6. 0	5. 8	2. 8
White	6. 5	6. 1	5. 9	2. 7
Nonwhite	4. 9	4. 5	4. 3	2. 7

those persons who survive the hazards of infancy exhibit an increase in the average number of years of life remaining over the number expected when they were 1 year younger. The 1958 values of expectation of life at age 1 are 68.1 years for white males, 74.2 years for white females, 62.8 years for nonwhite males, and 67.3 years for nonwhite females. The increase in expectation of life at age 1 over that at age 0 is substantial for nonwhite males and nonwhite females (2.2 and 1.8 years, respectively), but considerably smaller for white males and white females (0.9 and 0.5 years, respectively), and this reflects the higher infant mortality experience of the nonwhite population.

Values of expectation of life at specified older ages are also readily accessible from the life table. It may be of interest for certain purposes, for example, to examine average remaining lifetime at ages 20 and 65. Table 1 shows $e°_x$ values at these ages, which may be regarded as representing, respectively, the attainment of manhood and womanhood and the minimum retirement age, for men, prescribed by the Social Security Act. The 1958 values for expectation of life at age 20 are 50.0 years for white males, 55.9 years for white females, 45.0 years for nonwhite males, and 49.3 years for nonwhite females. Corresponding values at age 65 are 12.7, 15.4, 12.1, and 14.8 years. The higher expectation of life of white males over nonwhite females, which is apparent at ages 0 and 1, is considerably smaller at age 20 and absent at age 65.

The concept "expectation of life" may be misleading, for it may imply for some readers the notion of forecasting. It is important to understand that expectation of life values forecast average remaining lifetime, in years, at specified ages only for the hypothetical cohort of the life table. Forecasts of expectation of life in 1958 for any actual population must take into consideration not only mortality experience in 1958 but also mortality experience in subsequent calendar years. On the basis of observations for past years, it is highly probable that mortality experience in the Nation will continue to change. Therefore, the assumption that the current age-specific mortality rates are fixed, which underlies the construction of the life table, makes its expectation of life values inappropriate as forecasters of longevity in any actual population.

It is, however, possible to view the 1958 expectation of life values as forecasters of future mortality experience of the present population in a limited sense. Assuming that the mortality trend in the Nation will continue to decline for some years to come, the values of expectation of life in the current life table are minimum estimates of longevity for the actual population.

Quartile and Median Length of Life

From the values given in the life table, it is possible to calculate the ages at which specified proportions of the original life table cohort will have died—for example, the ages at which there remain alive, respectively, 75, 50, and 25 percent of the original cohort. For the 1958 abridged life tables, which start with cohorts of 100,000 live births, these are the ages at which there remain exactly 75,000, 50,000, and 25,000 survivors. In computing these percentile values, the assumption is made that deaths are evenly distributed within the relevant age intervals.

Table 2. Quartile length of life, by sex and color, United States, 1958

Sex and color	Age to which 75 percent of original cohort survives	Age to which 25 percent of original cohort survives
Male:		
White	60. 2	79. 9
Nonwhite	51. 2	74. 6
Female:		
White	68. 0	84. 8
Nonwhite	55. 7	80. 6

Table 2 shows those ages, based on 1958 life table values, at which exactly 25 and 75 percent of the original cohorts, by color and sex, are still alive. Among white males, 75 percent survive to age 60.2 and 25 percent to age 79.9; among white females, 75 percent survive to age 68.0 and 25 percent to age 84.8. These figures may be contrasted with those for the nonwhite population: among nonwhite males, 75 percent survive to age 51.2 and 25 percent to

age 74.6; among nonwhite females, 75 percent survive to age 55.7 and 25 percent to age 80.6.

The median length of life, also known as the "probable lifetime," is a special case of percentile analysis of life table survivorship. This is the age at which exactly half of the members of the original life table cohort have died or the age at which there remain exactly 50,000 survivors. Table 3 shows that median length of life at birth, on the basis of 1958 mortality rates, is 71.0 years for white males, 77.8 years for white females, 64.9 years for nonwhite males, and 68.6 years for nonwhite females.

A comparison of these "probable lifetime" measures with those for expectation of life at birth (table 3) shows that the former exceed the latter for each population group. Thus, for white males, median length of life at birth is 3.8 years longer than expectation of life at birth; for white females, 4.1 years; for nonwhite males, 4.3 years; and for nonwhite females, 3.1 years. These differences are, in large part, brought about by the high toll of mortality during the first year of life, which skews the distribution of deaths in such a manner that the median exceeds the mean.

Proportion Dying

The $_nq_x$ column of the life table, known as the proportion dying column, shows the proportion of the life table cohort who are alive at the beginning of an age interval and who will die before reaching the end of that age interval. These $_nq_x$ values represent probabilities that persons who are alive at the beginning of an age interval will die before reaching the

Table 3. Comparison of median length of life and expectation of life at birth, by sex and color, United States, 1958

Sex and color	Median length of life at birth	Expectation of life at birth (mean)	Excess: median over mean (years)
Male:			
White	71. 0	67. 2	3. 8
Nonwhite	64. 9	60. 6	4. 3
Female:			
White	77. 8	73. 7	4. 1
Nonwhite	68. 6	65. 5	3. 1

Table 4. Proportion dying ($_nq_x$) in specified age intervals, by sex and color, United States, 1958

Sex and color	Proportion dying in age intervals—			
	0–1 year	1–5 years	20–25 years	65–70 years
Total	0. 0270	0. 0044	0. 0062	0. 1587
Male:				
White	. 0267	. 0042	. 0084	. 1942
Nonwhite	. 0503	. 0077	. 0133	. 2808
Female:				
White	. 0206	. 0036	. 0029	. 1127
Nonwhite	. 0411	. 0072	. 0071	. 2105

beginning of the next age interval. Thus, for white males at age 0 in 1958, the probability of dying before reaching age 1 is 0.0267, or 26.7 chances out of 1,000 (table 4). At age 1 for white males, the probability of dying before reaching age 5 is reduced to 0.0042. Respective values for white females, nonwhite males, and nonwhite females are 0.0206, 0.0503, and 0.0411 in the age interval 0–1 and 0.0036, 0.0077, and 0.0072 in the age interval 1–5.

Survivors to Specified Ages

Other values which can be readily determined from the life table are the numbers, or percentages, of persons in the original cohort surviving to specified ages. Table 5 shows, on the basis of 1958 life tables, percentages of persons in the original cohorts surviving, respectively, to ages 1, 20, and 65. The percentage of white males in a cohort of 100,000 live births surviving to age 1 is 97.3; for white females, 97.9; for nonwhite males, 95.0; and for nonwhite females, 95.9. At age 20, respective percentages are 95.8, 97.0, 92.9, and 94.3; and at age 65, respective percentages are 65.6, 80.4, 49.7, and 58.8.

For all population groups, the proportion of whites surviving to each of these ages exceeds that of nonwhites, and the proportion of females exceeds that of males. These color and sex differentials may be expressed as percentages. Thus, for example, at age 20, the ratio of nonwhite male to white male survivors is 97 percent; at age 65, the ratio is 76 percent.

This marked difference indicates the cumulative effect of higher mortality among nonwhite males in the intervening years. For white and nonwhite females, the corresponding ratios are 97 percent and 73 percent.

Trends and Comparisons

Life table values for periods prior to 1929–31 are not strictly comparable with those for later periods. The geographic area covered in life tables prior to 1929–31 was limited by the size of the death-registration area. Life tables for 1929–31 and succeeding years cover the entire continental United States. This source of variation probably accounts, at most, for only a small part of the spectacular improvement in life table values observed over the entire period covered; however, it is believed that the fluctuations shown at certain ages in the values for nonwhites during the first 30 years of the century may be attributable, in part, to the character of the expanding death-registration area and, in part, to progressive improvement in the completeness of death registration.

Certain trends may, however, be noted since the turn of the century. Table 6 indicates increases in expectation of life, in years, at specified ages, from 1900–1902 to 1958. Since the turn of the century, expectation of life at birth has increased by 19.0 years for white males, 22.6 years for white females, 28.1 years for nonwhite males, and 30.5 years for nonwhite fe-

Table 5. Proportion of persons surviving to specified ages (l_x), by sex and color, United States, 1958

Sex and color	Population surviving to age—		
	1 year	20 years	65 years
	Percent		
Total	97. 3	96. 0	70. 8
Male	97. 0	95. 4	63. 8
White	97. 3	95. 8	65. 6
Nonwhite	95. 0	92. 9	49. 7
Female	97. 6	96. 6	78. 0
White	97. 9	97. 0	80. 4
Nonwhite	95. 9	94. 3	58. 8

Table 6. Increases in average remaining lifetime (e^0_x) at specified ages, United States, 1900–58

Sex, color, and age	Increase from—	
	1900–1902 to 1958	1929–1931 to 1958
	Years	
Male		
White:		
0	19. 0	8. 1
1	13. 5	6. 1
20	7. 8	4. 0
65	1. 2	. 9
Nonwhite:		
0	28. 1	13. 0
1	20. 3	11. 7
20	9. 9	9. 0
65	1. 7	1. 2
Female		
White:		
0	22. 6	11. 0
1	17. 8	9. 3
20	12. 1	7. 4
65	3. 2	2. 6
Nonwhite:		
0	30. 5	16. 0
1	23. 8	15. 0
20	12. 4	12. 1
65	3. 4	2. 6

males. It is apparent that improvements in this value have been substantially greater for the nonwhite than for the white population. Although, in 1958, values of e^0_0 for whites are still higher than those for nonwhites, the differential is of lesser magnitude than it was at the turn of the century. In 1900–1902, the white female of the hypothetical life table cohort could expect, at birth, to live 16.1 years longer than the nonwhite female; in 1958, the differential was reduced to 8.2 years. Comparable figures for males are, respectively, 15.7 and 6.6 years.

In short, when viewed in the context of color breakdown, that segment of the population originally having higher mortality rates has shown the greater relative improvement. This does not, however, hold true by sex breakdown. Females in both color groups, showing the longer expectation of life at birth in 1900–1902 as well as 1958, have had greater increases in this measure relative to males. In 1900–1902, expectation of life at birth for the white female

was 2.9 years longer than that for the white male; that for the nonwhite female was 2.5 years in excess of that for the nonwhite male. Comparable figures for 1958 are, respectively, 6.5 and 4.9 years.

In recent years, there has been an increasing interest in data on average length of life (e^0_0) for past single calendar years prior to initiation of the annual abridged life table series. In order to meet these needs, the National Office of Vital Statistics has computed estimates of such values (4); these are given, in part, in table 7. From these estimates, average annual increases in expectation of life at birth may be computed. Since the turn of the century, the total population has, on the average, each year added 0.38 year to its expectation of life at birth. During the same period, white males have added 0.36 year per annum; white females, 0.43 year per annum; nonwhite males, 0.48 year per annum; and nonwhite females, 0.55 year per annum. Such annual increases have not, however, been evenly distributed over the 59-year period.

Average annual increases for the period 1938–48 are, for example, more marked than those for the period 1948–58. Average annual increases in expectation of life at birth for 1938–48 were 0.23 year per annum for white males, 0.42 year per annum for white females, 0.64 year per annum for nonwhite males, and 0.82 year per annum for nonwhite females. Corresponding figures for 1948–58 are, respectively, 0.17 year, 0.27 year, 0.25 year, and 0.30 year. These statistics suggest that, although increases in expectation of life at birth are still taking place, the rate of increase is slowing down. Such a trend is altogether consistent with the trend of increasing control over the in-

Table 7. Estimated average length of life (e^0_0) in years, by color and sex, U.S. death-registration area, 1900–58

Year	Total population	White		Nonwhite	
		Male	Female	Male	Female
1958	69. 4	67. 2	73. 7	60. 6	65. 5
1953	68. 8	66. 8	72. 9	59. 7	64. 4
1948	67. 2	65. 5	71. 0	58. 1	62. 5
1943	63. 3	63. 2	65. 7	55. 4	56. 1
1938	63. 5	63. 2	66. 8	51. 7	54. 3
1933	63. 3	62. 7	66. 3	53. 5	56. 0
1928	56. 8	57. 0	60. 0	45. 6	47. 0
1923	57. 2	57. 1	59. 6	47. 7	48. 9
1918	39. 1	37. 1	43. 2	29. 9	32. 5
1913	52. 5	50. 8	55. 7	36. 7	40. 3
1908	51. 1	49. 9	53. 3	33. 8	36. 0
1903	50. 5	49. 5	52. 5	31. 7	34. 6
1900	47. 3	46. 6	48. 7	32. 5	33. 5

fectious and parasitic diseases. In past years, when the greatest advances in control of these diseases as leading causes of death were being made, there were correspondingly high increases in expectation of life at birth.

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